Sumner (Chas.)

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weights & measures

THE METRIC SYSTEM OF WEIGHTS AND MEASURES.

SPEECH

OF

HON. CHARLES SUMNER

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SPEECH.

IN SENATE, July 27th, 1865.—Mr. Sumner called up the bill and joint resolution reported by him from the special committee on the metric system of weights and measures, viz.: "A bill to authorize the use of the metric system of weights and measures;" "A joint resolution to authorize the Secretary of the Treasury to furnish to each State one set of the weights and measures of the metric system;" "A bill to authorize the use in post-offices of weights of the denomination of grains." The bills and joint resolution were considered and passed.

Mr. SUMNER,—Mr. President, at another time I might be induced to go into this question at some length; but now, in these latter days of a weary session, and under these heats, I feel that I must be brief. And yet I could not pardon myself if I did not undertake, even at this time, to present a plain and simple account of the great change which is now proposed.

There is something captivating in the idea of one system of weights and measures, which shall be common to all the civilized world; so that, at least in this particular, the confusion of Babel may be overcome. Kindred to this is that other idea of one system of money. And both of these ideas are, perhaps, the forerunners of that grander idea of one language for all the civilized world. Philosophy does not despair of the fulfilment of this aspiration at some distant day; but a common system of weights and measures and a common system of money are already within the sphere of actual legislation. The work has already begun, and it cannot cease until this great object is accomplished.

If the United States seem to come tardily into the circle of nations recognizing a common system of weights and measures, I confess that I have pleasure in calling attention to the historic fact that, at a very early day, this important subject was commended to Congress. Washington in his message to the First Congress touched the key-note when he used the word "uniformity" in connection with this subject. "Uniformity," he said, "in the currency, weights, and measures of the United States is an object of great importance and will, I am persuaded, be attended to." Then again in his message to the next Congress he went further in expressing a desire for a "standard at once *invariable and universal*." In these words he foreshadowed a system that should be common to the civilized world. It is for us now to recognize the standard which he thus sententiously described. All hail to a standard "invariable and universal."

I shall not occupy your time in developing the history of these efforts on the part of our Government. But I cannot forbear mentioning that Mr. Jefferson, while Secretary of State, made an elaborate report, in which he proposed to reduce "every branch to the same decimal ratio already established in coins, and thus bring the calculation of the principal affairs of life within the arithmetic of every man who can multiply and divide plain numbers." Here is an essential element in that common system which we seek to establish. This was in 1790, while France was just beginning those efforts which ended at last in the establishment of the metric system. The subject was revived at different times in Congress without definite result. President Madison, in his annual message of 1816, called attention to it in the following words:

> "The great utility of a standard *fixed in its nature and founded on the easy rule of decimal proportions* is sufficiently obvious. It led the Government at an early stage to preparatory steps for introducing it; and a completion of the work will be a just title to the public gratitude."

Out of this recommendation originated that call of the Senate which drew forth the masterly report of John Quincy Adams on the whole subject of weights and measures, where learning, philosophy, and prophetic aspiration vie with each other. After reviewing all that had appeared in the past, and subjecting it all to a careful examination, he says of the metric system of France, which was then only an experiment:

> "This system approaches to the ideal perfection of uniformity applied to weights and measures, and whether destined to succeed or doomed to fail, will shed unfading glory upon the age in which it was conceived and upon the nation by which its execution was attempted and has been in part achieved."

This was in 1821, when the metric system, already invented, was still struggling for adoption in France.

This brief sketch will show how from the beginning our Government has been looking to a system which shall be common to the civilized world. And now this aspiration seems about

to be fulfilled. The bills before you, which have already passed the other House, if they become a law, will be the practical commencement of the "new order."

Before proceeding to explain the proposed system, consider for one moment the necessity of a change, as illustrated by a glimpse at weights and measures in times past.

Language is, of course, coeval with man as a social being. Weights and measures are hardly less early in their origin. They are essential to the operations of society, and are naturally common to all who belong to the same social circle. At the beginning each people had a system of its own; but as nations gradually intermingle and distant places are brought together by the attractions of commerce, the system of one nation becomes inadequate to the necessities of the composite body. A common system becomes important, just in proportion to the community of interests among different nations. Next to the diversity of languages, the discordant systems of weights and measures attest the insulation of nations.

The earliest measures were naturally derived from the several parts of the human body. Such was the cubit, which was the distance between the elbow and the end of the middle finger, being about twenty-two inches. Such also, were the foot, the hand, the span, the nail, and the thumb. These measures were derived from nature, and they were to be found wherever a human being existed. But they partook of the uncertainty in the proportions of the human form. When Selden, in his Table-Talk, wittily likened equity, so far as it depended on the conscience of the chancellor, to a measure which was determined by the length of the chancellor's foot, he exposed not only the uncertainty of equity, but also the uncertainty of such a measure.

Even in Greece, where art prevailed in the most beautiful forms, the famous *stadium* was none the less uncertain. It was the distance that Hercules could run without taking breath, which, divided by 600, gave the Grecian foot.

Our own standards, derived from England, are of an equally fanciful character. The unit of *length* is the barleycorn, taken from the middle of the ear and well dried. Three of these in a straight line make an inch. The unit of *weight* is a grain of wheat taken, like the barleycorn, from the middle of the ear and well dried. Of these, thirty-two are equal to a pennyweight. Twenty pennyweights make an ounce, and twelve ounces make a pound. The unit of *capacity* is derived from the weight of grains of wheat. Eight pounds of these make one gallon of wine measure.

Nor is the extreme vagueness and instability of these standards the only matter of surprise. There is no principle of science or convenience in the progression of the different series. Thus we have two pints to a quart, three scruples to a dram, four quarts to a gallon, five quarters to an ell, five and a half yards to a perch, six feet to a fathom, eight furlongs to a mile, twelve inches to a foot, sixteen ounces to a pound, twenty units to a score.

Then, as if the only ruling principle which governed the selection was discord, we have different measures bearing the same name, such as the wine pint and the dry pint, the ounce Troy and the ounce avoirdupois. Take these two last measures as illustrating the prevailing confusion. They both seem to come from France. The Troy weight is supposed to derive its name from the French town of Troyes, where a celebrated fair was once held. The term *avoirdupois* is French, and seems to have been part of a statute which declared how weights should be determined. But Troy and avoirdupois are different measures.

These measures, having constant differences, had accidental differences also, in different parts of England, and also in different parts of our own country. Even where the names are alike the measures are often unlike. In England the diversity was almost infinite, so that these same measures differed in different counties, and sometimes in different towns of the same county. Latterly in the United States the standard has been regulated by law, but the confusion from the measures still continues. The question naturally arises why such confusion has been allowed to continue so long without correction. The answer is easy. Except in rare instances the triumphs of science are slow and gradual. Traditional prejudices must be overcome. Each nation is attached to its own imperfect system, as to its own language. Even though inferior to another system, it has the great advantage of being already known to the people that use it. To this constant impediment it is only proper to add the intrinsic difficulty of establishing a uniform system of weights and measures which shall satisfy the demands of civilization in scientific precision, in immediate practical applicability, and in nomenclature.

Take, for instance, the application of the decimal system, which seems at first sight simple and complete. It is unquestionably an immense improvement on the old confusion; but even here we encounter a difficulty in the circumstance, long since recognized by mathematicians, that our scale of decimal arithmetic is more the child of chance than of philosophy. I know not if any better reason can be given for its adoption than because man has everywhere reckoned by his ten fingers. On this account it has been often called "natural." But on considering whether the number *ten* possesses any intrinsic excellence, convenience, or fitness as a ratio of progression, good authorities have answered in the nega-

tive. It is the duplication of an odd number which can furnish, neither a square or a cube, and which cannot be halved without departing from the decimal scale. In this scale we seem to see always those early days when "wild in woods the noble savage ran," and for his arithmetic used his fingers or his toes. An *octaval* system, founded on the number eight, would have been better adapted to the divisions of material things. Among us the decimal system is adopted for money; but you all know that we are not able to carry it into rigid practice. Thus convenience, if not necessity, requires the half dollar, the quarter dollar, the half dime, and the three-cent piece. In fact, eight divisions to the dollar, as prevailed in Spain, are available in the business of life, more than the decimal division. The number *eight* is capable of an indefinite bisection. The progression beginning with 2 would proceed to 4, 8, 16, 32, 64, and so on.

The decimal scale is made easy of use by the happy system of notation borrowed from the Hindoos, which might be applied equally well to an octaval scale. But at this time, it would be vain to propose a change in the radix of the numerical scale. The number *ten* is the recognized starting point, and gives its name to the scale. It only remains for us at present to follow other nations in applying it to an improved system of weights and measures.

A system of weights and measures born of philosophy rather than of chance, is what we now seek. To this end old systems must be abandoned. A chance system cannot be universal. Science is universal. Therefore, what is produced by science may find a home everywhere. If we consider the proper elements or characteristics of such a system we shall find at least three essential conditions. First, the new system must have in itself the assurance of unvarying stability, and, to this end, it should be derived from some standard in nature by which any errors creeping into the weights and measures, from time or imperfect manufacture, may be corrected. Secondly, the parts should be divided decimally, as nearly as practice will warrant, in conformity with our arithmetic. Thirdly, it should be of such a character as to disturb national prejudices as little as possible.

To a common observer the difficulties of finding an unvarying standard are not readily apparent; but philosophy shows that all things in nature are undergoing a constant change, so that there would seem to be no invariable magnitude, the same in all countries and in all times, as Cicero described the great principles of Natural Law, by which a lost standard on an inaccessible island might be reproduced with mathematical certainty. There is but one magnitude in nature, which, so far as we know, approximates to these requisites. I refer, of course, to the length of the pendulum, vibrating seconds, which in our latitude is about 39.1 inches. This length, however, varies in traveling from the equator to the pole, and it also varies slightly under different meridians and the same latitude; but the law of variation has been determined with considerable accuracy. One element in this variation is the difference of temperature. Mr. Jefferson, in his report, on weights and measures, proposed that we should find our standard in the pendulum. At the same time the French Government, just struggling to throw off ancestral institutions, conceived the idea of a new system of weights and measures which, founded in science, should be common to the civilized world.

The French began not only by discarding all old systems, but also by discarding a measure derived from the pendulum. They conceived the idea of measuring an arc of the meridian of the earth, and finding a new unit in a subdivision of this immense span. At the same time the National Assembly invited the co-operation of other nations, so that the system should become universal. The work proceeded. An arc of the meridian, embracing upward of nine degrees of latitude, and extending from Dunkirk, in France, to the Mediterranean near Barcelona, in Spain, was measured with the most scientific care. Some of the most illustrious names in French science were engaged in it, of whom I may mention Mechain, Delambre, Biot, and Arago, the latter just beginning his great career. The work proceeded, notwithstanding domestic convulsion and foreign war. The reign of terror at home and invasion from abroad did not arrest it. Ten years elapsed before the measurements were completed, when again other nations were invited to coöperate in the establishment of the new system.

The unit of measure adopted was one ten millionth part of the distance between the equator and the north pole thus measured. It receives the name of *metre*, from the Greek, signifying *measure*. A bar of platinum was carefully prepared representing this length with all possible accuracy. This bar was deposited in the archives of France as the perpetual standard. Other bars have been copied from it and distributed throughout France and in foreign countries.

There is something transcendental in the idea of this measurement of the earth in order to find a measure for daily life. It was an immense undertaking. But the conception seems to have been rather vast than practical. There is reason to believe, from later labors, that there was a serious error in the work. Thus the distance of 10,000,000 meters from the equator to the north pole, established by the French observers, is too small by 935 yards, according to Bessel; by 1,410 yards, according to Puissant; and by 1,967 according to

Chazallon. Sir John Herschell has also testified with the authority of his great name against the accuracy of this result. If there be an error, such as is supposed, then the meter ceases to be what it was originally called, one ten millionth part of the distance from the equator to the north pole.

Even assuming that there is no error, and that the meter is precisely what it purports to be, yet it is not easy to see how the artificial standard can be corrected by a recurrence to the standard in nature. The massive work originally undertaken will not be repeated. The astronomers of France will not verify the accuracy of the bar of platinum which is the artificial standard, by another scientific enterprise, requiring years for its completion. Therefore, for all practical purposes the meter is really nothing else than a bar of platinum of a certain length preserved in the archives of France. It is not less arbitrary as a standard than the yard or foot, and it can be perpetuated in practice only by the distribution of exact copies of the original bar, which is the assumed meter.

I have entered into this explanation of the origin and character of the meter because I desire that the admirable system which is founded on it should be seen actually as it is. To my mind it gains nothing from the theory which presided at its origin. Its unit is not to be regarded as a certain portion of the distance between the equator and the north pole, but as an artificial measure determined with peculiar care. Had the same or any other measure been selected, without any measurement of the earth, the metric system would not have been less beautiful or perfect.

Look now at the system. The meter, which is assumed to be one ten millionth part of the distance from the equator to the poles, is, in fact, 39⅜ inches or 39.37 inches in length. It is especially the unit of *length*, but it is also the unit from which all measures of weight and capacity, square or cubic, are derived. It is at once foundation-stone and cap-stone to the whole system. It is foundation-stone to all in the ascending series and cap-stone to all in the descending series.

The unit of *measures of surface* or land measures is the *are*, from the Latin *area*, and is the square of ten meters, or, in other words, a square of which each side is ten meters in length.

The unit of *solid measure* is the *stere*, from the Greek, and is the cube of a meter, or, in other words, a solid mass one meter long, one meter broad, and one meter high.

The unit of *liquid measure* is the *liter*, from the Greek, and is the cube of the tenth part of the meter, which is the *decimeter*, or, in other words, it is a vessel, where by interior measurement each side and the bottom are square *decimeters*.

The unit of weight is the *gram*, also derived from the Greek, and is the one-thousandth part of the weight of a cubic liter of distilled water—at its greatest density—this being just above the freezing point.

Such are the main elements of the metric system. But each of these has its multiples and its subdivisions. It is multiplied decimally upward and divided decimally downward. The multiples are derived from the Greek. Thus, *deca*, ten; *hecto*, hundred; *kilo*, thousand; and *myria*, ten thousand, prefixed to meter, signify ten meters, one hundred meters, one thousand meters, and ten thousand meters. The subdivisions are derived from the Latin. Thus *deci*, *centi*, *milli*, prefixed to meter, signify one-tenth, one-hundredth, and one-thousandth of a meter. All this will appear in the following table:—

Metric denominations and values.	*Equivalents in denominations in use.*
Myriameter, 10,000 meters,	6.2137 miles.
Kilometer, 1,000 meters,	.62137 mile, or 3,280 feet and 10 inches.
Hectometer, 100 meters,	328 feet and 1 inch.
Decameter, 10 meters,	393.7 inches.
METER, 1 meter,	39.37 inches.
Decimeter, 1-10 of a meter,	3.937 inches.
Centimeter, 1-100 of a meter,	.3937 inch.
Millimeter, 1-1000 of a meter,	.0394 inch.

These same prefixes may be applied in ascending and descending scales to the are, the liter and the gram. Thus, for example, we have in the ascending scale, *deca*gram, *hecto*gram, *kilo*gram, and *myria*gram; and in the descending scale, *deci*gram, *centi*gram, *milli*gram.

In this brief space you behold the whole metric system of weights and measures. What a contrast to the anterior confusion! A boy at school can master the metric system in an afternoon. Months, if not years, are required to store away the perplexities, incongruities, and inconsistencies of the existing weights and measures; and then memory must often fail in reproducing them. The mystery of compound arithmetic is essential in the calculations which they require. All this is done away by the decimal progression, so that the first four rules of arithmetic are ample for the pupil.

If we look closely at the metric system we must confess its simplicity and symmetry. Like every creation of science, it is according to rule. Master the rule and you master the system. On this account it may be acquired by the young with comparative facility, and when once acquired it may be used with dispatch. Thus it becomes labor-saving and time-saving. I cannot hesitate to mention among its merits the nomenclature which it has adopted. A superficial criticism has objected to the Greek and Latin prefixes; but this forgets that a system intended for univer-

sal adoption must discard all local or national terms. The prefixes employed are equally intelligible in all countries. They are no more French than English or German. They are in their nature common or cosmopolitan. And in all countries they are equally suggestive in disclosing the denomination of the measure. They combine the peculiar advantages of a universal name and a definition. The name instantly suggests the measure with exquisite precision. If these words seem to be scholastic or pedantic you must bear this for the sake of their universality and defining power.

Unquestionably it is difficult for a generation to substitute a new system for that which it learned in childhood. Even in France the metric system was tardily adopted. Napoleon himself, on one occasion, said impatiently to an engineer who answered his inquiry in meters—"What are meters? Tell me in *toises*." It was only in 1840 that the system was definitely required in the transaction of business. Since then it has been the legal system of France. Cloth is sold by the meter. Roads are measured by the kilometer. Meat is sold by the kilogram, or as it is familiarly abridged, by so many *kilos*.

It is generally admitted that the names are too long, although nobody has been able to suggest substitutes, unless we regard the various abridgments in that light. But no abridgment should be allowed to sacrifice that cosmopolitan character which belongs to the system. Thus in England a nomenclature has been proposed which would secure short names; but these names would be different in each language, and would be entirely different from the French names. This is a mistake. The names in all languages should be identical, or so nearly alike as to be recognized at once. This may be accomplished by an abbreviated nomenclature.

For instance, we may say *met*, *ar*, *lit*, and *gram;* and, in describing the denomination, we may say in the ascending scale *dec*, *hec*, *kil*, and in the descending scale *dec*, *cen*, and *mil*, indicating respectively 10, 100, 1000, and 1-10, 1-100, and 1-1000. Compounding these words we should have, for example, *kilmet*, *killit*, *kilgram*, and *cenmet*, *cenlit*, *cengram*. These abbreviations might be substantially the same in all languages. They would preserve the characteristics of the unabridged terms, so that the simple mention of the measure, even in this abridged form, would disclose the proportion which it bears to its fellow-measures. Previous measures have been represented by monosyllables; as grain, dram, gross, ounce, pound, stone, ton. Where a word is often repeated in the hurry of business it is instinctively abridged. We shall not err if we profit by this experience, and seek to reduce the new nomenclature to its smallest proportions.

Twelve words are all that are required by this system. In learning these you learn all. There are the five words designating the different units of length, surface, solid capacity, liquid capacity, and weight. Then there are the seven prefixes, being four in the ascending scale, expressing *multiples* or augmentations of the meter or other units, derived from the Greek; and also three in the descending scale, expressing subdivisions or diminutions of the meter and other units, derived from the Latin. These twelve words contain the whole system.

In closing this chapter of the unquestionable advantages of the metric system, I must not forget that it is already the received system in the majority of countries. Thus it appeared at the Statistical Congress assembled at Berlin in 1863, that it was adopted partly or entirely in Austria, Baden, Bavaria, Belgium, France, Hamburg, Hanover, Hesse, Mecklenburg, the Netherlands, Parma, Portugal, Saxony, Sardinia, Spain, Switzerland, Tuscany, the Two Sicilies, and Wurtemburg. Since then Great Britain, by an act of Parliament, has added her name to this list. The first step is taken there by making the metric system *permissive*, as is now proposed in the bills before Congress. The example of Great Britain is of especial importance to us, since the commercial relations between the two countries render it essential that there should be a common system of weights and measures. On this point we cannot afford to differ from each other.

The adoption of the metric system by the United States will go far to complete that circle by which this great improvement will be assured to mankind. Here is a new agent of civilization which will be felt in all the concerns of life, at home and abroad. It will be hardly less important than the Arabic numerals, by which the operations of arithmetic are rendered common to all nations. It will help undo that primeval confusion of which the Tower of Babel was the representative.

As the first practical step to this great end I ask the Senate to give its sanction to the bills which have already passed the other House, and which I have reported from the special committee on the metric system. By these enactments the metric system will be presented to the American people, and will become an approved instrument of commerce. It will not be forced into use, but will be left for the present to its own intrinsic merits. Meanwhile it must be taught in schools. Our arithmetics must explain it. They who have already passed a certain period of life may not adopt it; but the rising generation will embrace it and ever afterwards number it among the choicest possessions of an advanced civilization.